No. XIII.

On the Geological Formation of the Natural Bridge of Virginia. By Francis William Gilmer.—Read February 16, 1816.

IT is chiefly to Mr. Jefferson that naturalists are indebted for their knowledge of this beautiful and uncommon accident in the structure of mountains. The description which our distinguished philosopher has given of it in his Notes on Virginia, not only excited the curiosity of the learned, but induced the French general Marquis of Chatelux, to have an exact draught of it made by one of his engineers; from which both Europe and America were supplied with plates, which have justified the admiration excited by the description of Mr. Jefferson.

This object is not only singular in its structure, but, in a high degree, picturesque and romantic. And though Mr. Jefferson, with whom I had the pleasure of visiting it in the autumn of 1815, thinks it has lost some of its embellishments in 50 years of invasion upon the trees which crowned its borders, and overhung its sides, it still retains enough of its beauty and grandeur to vindicate all the pretensions which such fortunate patronage could give it.

The bridge is situated on Cedar Creek, a small stream in the county of Rockbridge. The channel of this creek is, for some distance both above and below the bridge, a deep, narrow

ravine, with almost perpendicular sides of rock, disposed in unequal, horizontal strata. The fissures between these strata are sometimes so large as to give growth to Kalmia, Thuia, Abies, and many mosses and lichens, whose perpetual verdure is agreeably contrasted with the blue limestone. The hills about the bridge are covered with the ordinary forest trees of this part of Virginia. Tilia, Cercis, Thuia, Abies, Liriodendron, Fagus, and many species of Quercus. In the aspect of the country there is nothing peculiarly beautiful or striking. You follow the road which lies on a transverse ridge of hills, crossing the ravine by the bridge, until you are near the object of your philosophical pilgrimage, without observing any indication of its approach. It is not until you are very near, that you perceive a deep cleft in the earth;—you rush to its side, impatient to examine so unexpected a phenomenon. The curiosity of most persons, however, is overcome by fear, before they reach the margin of the precipice; they either abandon the enterprise, or timidly accomplish it by resting on a tree or rock, while they peep into the chasm which yawns beneath. While standing on the brink of this awful object, I had an opportunity of taking its height with a chord, more accurately than some others, who have made it much beyond what it really is, from the principles of a fallacious calculation.

	Feet.
The height of the lower surface of the arch above the water is about	160
The thickness of the arch varies from a much greater extent to	35
The height of the upper surface or top of the arch,	*200

Such is the effect of the great elevation of the arch, that though more than 30 feet thick, it possesses all the lightness and elegance of Ionic proportions. It only wants a curvature

* It has been said to be as much as 270 feet. Mr. Jefferson found its latitude to be north, 37°, 42′, 44″.

rather more regular, to give it the graceful symmetry of the most beautiful works of art. After the curiosity is satisfied, the mind passes from the contemplation of an object, so wonderful in its structure, and vast in its dimensions, to consider the operations of nature which could produce so extraordinary a phenomenon.

Theories have already been attempted for explaining the formation of the Natural Bridge. As they were generally formed in the age of the mechanical philosophy, before geology or even chemistry had become sciences, we need not wonder to find the solutions they offered, very insufficient. Mr. Jefferson's hypothesis rested entirely upon the supposition, that some sudden and violent convulsion of nature, tore away one part of the hill from the other, and left the bridge remaining over the chasm. This, however, is referring to an agent whose existence even is unknown, and in explaining one phenomenon, involves us in greater difficulties by requiring an explanation of a still greater one;—unless this sudden convulsion be supposed to have been an earthquake, in which case the indications of its existence would have been numerous, and not a few solitary ones. Besides, there are no corresponding *salliant* and receding angles, which would have been a circumstance necessarily attending this violent emotion and severance of one part of the hill from the other. And why should the bridge remain, more than any other part of the surface, across the ravine? This hypothesis then, however ingenious it be, when we consider the age of science in which it appeared, must be rejected as contradicting a rule which is necessary to impart to fiction some degree of veri-similitude:

"Nec Deus intersit nisi dignus vindice nodus."

It contradicts, also, that beautiful and valuable rule laid down by Newton, "that it is unphilosophical to assign more causes for the natural appearance of things than are both true, and sufficient to account for the phenomena." The certainty of

the existence of a cause is an inquiry which must always precede the admission of any effect from it.

In the present state of geology, the phenomenon does not require us to resort to the operation of unknown, or even of doubtful agents. And instead of its being the effect of a sudden convulsion, or an extraordinary deviation from the ordinary laws of nature, it will be found to have been produced by the very slow operation of causes which have always, and must ever continue, to act in the same manner.

To make this manifest, let us consider the situation of the bridge. That the place at which it stands is the highest point of a transverse ridge of hills, with a narrow base, which crosses the ravine at that spot. The country about the bridge, like all that which is west of the mountains, from the Atlantic to the Pacific ocean, is calcareous.* The strata of rock, which at different places make different angles with the horizon, are here parallel to it. This rock is soluble in water to such a degree, as to be found in solution with all the waters of the country, and is so soft as to yield not only to its chemical agency, but also to its mechanical attrition. Here, as in calcareous countries generally, there are frequent and large fissures in the earth, which are sometimes conduits for subterraneous streams, called 'sinking rivers,' 'sinking creeks,' &c. of which there are several in the western parts of Virginia, Kentucky, and Tennessee. It is probable, then, that the water of Cedar Creek originally found a subterraneous passage beneath the arch of the present bridge, then only the continuation of the transverse ridge of hills. The stream has gradually widened, and deepened this ravine to its present situation. Fragments of its sides also yielding to the expansion and contraction of heat and cold, tumbled down even above the height of the water. Or, if there was no subterra-

* There have also been found near the sea similar arches, formed by the chemical and mechanical action of its waters. There is both the figure and description of one in Capt. Cooke's Voyages, which was found in New Zealand, and there is something of the same kind in the Island of Jersey, as we learn from the Memoirs of the English Geological Society.

neous outlet, the waters opposed by the hill flowed back, and formed a lake, whose contact dissolved the resistance where it was least, wore away the channel through which it now flows, and left the earth standing above its surface. I incline, however, rather to the first hypothesis, because the ravine has the appearance, from its narrow banks, of having been the channel of a stream in all time, and had it been the bed of a lake, the continued action of the water would have widened it into a basin. The stone and earth composing the arch of the bridge, remained there and no where else; because, the hill being of rock, the depth of rock was greatest above the surface of the water where the hill was highest, and this part being very thick, and the strata horizontal, the arch was strong enough to rest on such a base.

The same circumstances having concurred, the same phenomenon has been produced in Scott county, lately a part of Washington county, in Virginia. There is, over Stock Creek, a branch of Clinch River, a bridge, whose height is estimated at 300 feet, with a thicker arch; whose formation, in every material respect, resembles that of its more celebrated rival of Rockbridge. Indeed, the numerous subterraneous caverns which are found in this range of country, and which were formed in the original crystallization of the rock, only require a section of their ends to be taken away to become natural bridges, and these ends remain, only because their arches are thick enough to support the superincumbent weight. This, however, may, in the endless flow of time, cease to be the case, and caves may become bridges, and bridges cease to exist.

If it be difficult to carry our minds so far forward as to embrace such great changes, produced by causes operating so slowly, we may assist their operation by recollecting a still more prodigious effect of the same agent. At Reizi in Switzerland, a few years since, an entire mountain was excavated by a stream, part of it fell down, and inundated the neighbouring country by obstructing the waters of the river.

Indeed, the very process by which the natural bridge was formed, is still visibly going on; the water, which is accidentally thrown entirely on the western side, is excavating the rock, and widening the channel, which, after a long lapse of time, may become too wide to support the arch, and this wonder of our country will disappear—indicating, in all its mutations, the uniformity of the operations of nature, showing as well by its decay as by its present situation, an effect, different only in degree, of the same undeviating power.